PATENT ABSTRACTS OF JAPAN

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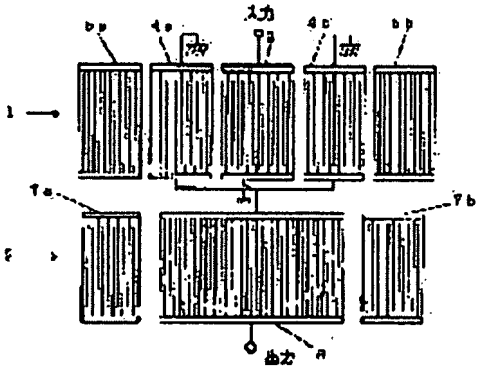
(71)Applicant : TOYO COMMUN EQUIP CO LTD

(72)Inventor : HIROTA KAZUHIRO
OGAWA YUJI

(54) SURFACE ACOUSTIC WAVE FILTER

(57)Abstract:

PROBLEM TO BE SOLVED: To suppress the increase in a loss and to obtain an excellent cut-off characteristic and an attenuation characteristic in the vicinity of high frequencies by connecting a resonator to terminals of IDTs at both sides among three interdigital transducers(IDTs).



SOLUTION: A longitudinally coupled dual mode surface acoustic wave (SAW) filter (longitudinally coupled DMS filter) 1 of 3-IDT configuration is made up of IDTs 3, 4a, 4b and reflectors 5a, 5b. A pattern pitch, number of electrodes and an interval of electrodes are selected to realize a desired pass band. A SAW resonator 2 is connected in series with an output terminal obtained by connecting electrodes of the IDTs 4a, 4b in parallel. The resonator 2 is made up of the IDT 6 in which electrode finger cross lengths to stimulate a surfaced acoustic wave are given a cosine type, weighting and reflectors 7a, 7b on its both sides. The resonance frequency of the resonator 2 is set to be in the pass band of the filter 1 and the anti-resonance frequency is set to be on the high frequency side of the pass band of the filter 1.

LEGAL STATUS

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* NOTICES *

CLAIMS

[Claim(s)]

[Claim 1] It has three IDT(s) arranged along the propagation direction of a surface acoustic wave on a piezo-electric substrate, and two reflectors arranged on these both sides of IDT. While connecting two IDT(s) of both sides to juxtaposition among said three IDT(s), IDT which carried out cosine mold weighting is connected to one of the connection terminals. And the surface acoustic wave filter characterized by having arranged the reflector on the both sides and setting antiresonant frequency as the pass band of said filter for the resonance frequency of this resonator rather than the pass band of said filter at a RF side.

[Claim 2] The surface acoustic wave filter according to claim 1 characterized by using 36 rotation Y cut lithium tantalate for said piezo-electric substrate.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the surface acoustic wave filter which has improved the magnitude of attenuation by the side of a pass band cut-off characteristic and high region close attendants especially along the surface-wave propagation direction on three INTADIJITARU transducers (henceforth IDT), and this maximum outside of IDT about the surface acoustic wave filter (henceforth an SAW filter) which comes to arrange two reflectors on a piezo-electric substrate.

[0002]

[Description of the Prior Art] Since a surface acoustic wave has the various descriptions it is featureless to the conventional oscillating device -- that the oscillating field is limited to a front face, and the amplitude and a phase can be designed separately -- also in the field of a fundamental research, research also accomplishes an applied field energetically, and it is used for various kinds of equipments by current. Since it is suitable for small and mass production method it is strong and according to batch processing and low cost is expectable especially, it is mostly used for the latest mobile communications, especially the latest cellular phone. In Proc.of 1980 IEEE Ultrasonics Symposium pp.164-168, it is especially proposed by Rosenberg R.L. and Coldren L.A., and the vertical joint duplex mode SAW filter (henceforth a vertical joint DMS filter) of 3IDT configurations put in practical use by Morita, Watanabe and others in Institute of Electronics, Information and Communication Engineers technical report US-92-8 is low loss, and the pass band has the outstanding description that it is flat and a cut-off can realize a steep property.

[0003] The mimetic diagram of the vertical joint DMS filter of the 3above-mentioned IDT configurations is shown in drawing 5 . On the main front face of the piezo-electric substrate 8, a vertical joint DMS filter has the structure which approached and has arranged Reflectors 11a and 11b along the propagation direction on the maximum outside of IDT(s) 9, 10a, and 10b and this IDT, uses as an input terminal one side of the electrode with which IDT9 counters, and grounds another side. furthermore, drawing 5 -- like -- IDT(s) 10a and 10b -- common connection of one [each] electrode is made, it considers as an output terminal, and the electrode of another side is grounded. Here, an input terminal and an output terminal may be decided for convenience, and may be replaced mutually.

[0004] the optimal location and allocation of IDT(s) 9, 10a, and 10b and Reflectors 11a and 11b shown in drawing 5 -- the bottom of said IDT -- an acoustic turnover -- being generated -- the result -- two -- it shuts up and the mode, i.e., the primary longitudinal mode and the Miyoshi longitudinal mode, is excited by stress. If the frequency in these modes is set to f1 and f3, respectively, it will be f3<f1 and the vertical joint DMS filter of 2 (f1-f3) will be obtained [center frequency] for bandwidth by f1. An example of the filtering property at the time of forming a vertical joint DMS filter on a 36-degree Y-X lithium tantalate (LiTaO3) substrate at drawing 6 is shown. The unsymmetrical property produced in the high region side near the pass band is an essential fault spurious and peculiar to a vertical joint DMS filter decided by the logarithm of I/O IDT so that more clearly than drawing 6 . Only about 12-13dB, the spurious magnitude of attenuation does not exist, and when it is going to apply to RF filter for cellular phones with which the frequency of transmission and reception is close, it poses a big problem.

[0005] As shown in drawing 7 as a means to solve spurious one near [above-mentioned] the pass band, the 1 terminal pair mold resonators 13 and 14 are connected to I/O of the vertical joint DMS filter 12 at a serial, and the proposal which is going to improve the magnitude of attenuation by the side of the high

region near the pass band is performed using the attenuation pole constituted from antiresonant frequency of these resonators. (The 1994 SHINGAKUKAI autumn convention besides Nagatsuka, No.1, P.230, JP,7-30367,A, JP,7-86870,A)

[0006] The above-mentioned improvement approach is explained using drawing 8 . Drawing 8 R> 8 (a) shows the circuitry Fig. which connected the 1 terminal pair mold SAW resonator (henceforth a SAW resonator) to the serial, respectively to I/O of a vertical joint DMS filter (DMSF and brief sketch). Drawing 8 (b) is what showed the filtering property (equivalent to drawing 6 R> 6) of said vertical joint DMS filter, and spurious one mentioned above to the high region side near the pass band has generated it. Drawing 8 (c) is what showed the transmission characteristic of a SAW resonator, and it means that an attenuation pole is generated in antiresonant frequency. The resonance frequency of this SAW resonator is set up so that it may be mostly in agreement with the pass band of said vertical joint DMS filter, and it sets up so that it may be mostly in agreement with the frequency in which spurious one in the high region side near the pass band of said vertical joint DMS filter generates antiresonant frequency further. Thus, if series connection of the SAW resonator which set up the frequency is carried out to a vertical joint DMS filter like drawing 8 (a), a comprehensive filtering property will turn into a property which has improved spurious one of a vertical joint DMS filter, as shown in drawing 8 (d).

[0007] An example of the actual measurement of said SAW resonator is shown in drawing 9 . Drawing 9 (a) shows the Smith chart Fig. showing the frequency-impedance locus of a SAW resonator, the horizontal line of a diameter of circle expresses a resisted part (r), and the upper half of a circle expresses a forward reactance (+jx), and it expresses the reactance (-jx) negative in a lower half. That is, the frequency which crosses the horizontal line of a diameter is a frequency of phase zero, and the number wave number A of resonance or antiresonant frequency B is expressed. There is no locus which draws a circle by the RF close-attendants side of antiresonant frequency B, and the frequency-impedance

characteristic of the SAW resonator which arranged the usual normal mold IDT has not produced resonance so that clearly from the Smith chart Fig. shown in drawing 9 (a). Moreover, measurement of the transmission characteristic of said SAW resonator shows the single peak response in antiresonant frequency, as shown in drawing 9 (b). The example of a filtering property of the filter constituted like drawing 7 using the resonator of such a normal mold IDT is shown in drawing 10 . Bandwidth of a frequency is about 36MHz in about 1.5GHz. the SAW resonator which carries out series connection to a vertical joint DMS filter -- either of the I/O of a piece or at least two pieces or more -- one side -- good -- it could carry out and the frequency of resonators may be shifted mutually.

[0008] Since the resonance frequency of the above-mentioned SAW resonator which carries out series connection usually sets up so that it may come in a filter pass band mostly, the increment in the loss in the passband by SAW resonator addition is small. However, if the resonant resistance of a SAW resonator is the order which is about 1ohm at all and series connection of two or more resonators is carried out, it is clear to cause the increment in loss and to become a problem. Moreover, at the antiresonance point of one resonator, since the frequency range which can keep attenuation large is narrow, in the case of circuitry like drawing 7 , it is common to shift the antiresonant frequency of two resonators a little mutually, and to arrange it, but the increment in loss of a pass band becomes twice [about] in the case of a resonator piece in this case.

[0009] Drawing 10 is the example of a filtering property of a configuration of having carried out series connection of the SAW resonator to each input/output terminal of a vertical joint DMS filter like drawing 7 , and has connected the SAW resonator with a low frequency to the center IDT (input) side shown in drawing 7 . Although the spurious magnitude of attenuation in the RF side of a pass band has improved, a cut-off characteristic is not smooth and a part like a plateau remains. If the antiresonant frequency of said SAW resonator is made to approach a filter pass band side further in order to remove spurious one like this plateau, it will become the property that the right shoulder of a pass band

property is missing like ** shown in drawing 11 .

[0010]

[Problem(s) to be Solved by the Invention] However, in the magnitude-of-attenuation improvement by the series connection of the conventional SAW resonator, when the magnitude of attenuation was secured in the to some extent large range, two or more SAW resonators which shifted antiresonant frequency were needed. Moreover, frequency relation of the height of the SAW resonator linked to each input/output terminal of a vertical joint DMS filter might not be specified, and a cut-off characteristic might not become smooth by the case, but the right shoulder of a filter pass band property might be missing. This invention is made in order to remove these faults, in a frequency range larger than before, the fixed magnitude of attenuation is secured by one resonator, and it aims at minimizing the increment in loss of a pass band, and offering the surface acoustic wave filter which has a good cut-off characteristic.

[0011]

[The means for solving invention] This invention in order to attain the above-mentioned purpose in claim 1 Two reflectors are arranged along the propagation direction of a surface acoustic wave on the maximum outside of three IDT(s) and this IDT on a piezo-electric substrate. Central IDT in an input terminal and the surface acoustic wave filter of both sides which carried out parallel connection of the two IDT(s), and was made into the output terminal to a serial It is the surface acoustic wave filter which connected the 1 terminal pair mold surface acoustic wave resonator which consists of IDT which carried out cosine mold weighting, and a reflector of the both sides, and has arranged antiresonant frequency for the resonance frequency of this resonator rather than the pass band of said filter to the pass band of said filter at the RF side. Furthermore, in claim 2, it is the surface acoustic wave filter which used 36 rotation Y cut lithium tantalate for the piezo-electric substrate.

[0012]

[Embodiment of the Invention] Hereafter, this invention is explained to a detail

based on the gestalt and experimental result of operation which were shown in the drawing. Drawing 1 is the mimetic diagram of the IDT electrode in which the configuration of this invention was shown, the vertical joint DMS filter 1 which consists of 3IDT(s) constituted from IDT(s) 3, 4a, and 4b and reflectors 5a and 5b of this maximum outside of IDT is the same as that of the conventional thing, and the pitch of a pattern, an electrode number, spacing of each electrode, etc. are chosen so that a desired pass band may be realized. Using one electrode of the center IDT3 of the vertical joint DMS filter 1 as an input terminal, an other-end child grounds. Moreover, parallel connection of one [each] electrode of IDT(s) 4a and 4b is carried out, it considers as an output terminal, and each other-end child is grounded. Furthermore, the SAW resonator 2 is connected to said output terminal at a serial. The SAW resonator 2 consists of IDT6 in which the decussation length of the electrode finger which excites SAW did cosine (cos) mold weighting, and reflectors 7a and 7b of the both sides. Moreover, these [IDT] and the electrode pattern of a reflector are produced with aluminum or an aluminium alloy on the principal plane of a piezo-electric substrate.

[0013] The main point of this invention makes a cosine configuration the electrode finger decussation length of IDT of a SAW resonator who connects with a vertical joint DMS filter at a serial, and are the comprehensive filtering property of a filter, and improving the improvement of the magnitude of attenuation by the side of the RF near the pass band, and the cut-off characteristic of a pass band especially. The advantage at the time of connecting the advantage and SAW resonator at the time of giving cosine mold weighting or weighting near this to IDT6 to the both-sides IDT (output) side of a filter 1 is explained. The measurement result of a SAW resonator which becomes this invention at drawing 2 is shown. Drawing 2 (a) is the Smith chart Fig. of the frequency-impedance characteristic at the time of producing the SAW resonator 2 on a 36-degree Y-X lithium tantalate ($LiTaO_3$) substrate, and has the locus which draws a small circle near antiresonant frequency B. It is clear that small resonance of Q exists in a frequency somewhat higher than antiresonant frequency B from

from a configuration of drawing 1 , i.e., a vertical joint DMS filter and one SAW resonator, and the decussation finger of a SAW resonator was obtained using IDT of a cosine configuration, and it has realized the steep cut-off characteristic, without the right shoulder of a filter pass band being missing. Although especially the filtering property is not illustrated since a filter shape is common knowledge, compared with the case where the SAW resonator of the normal mold IDT is used, a cut-off characteristic is steep, its attenuation with antiresonant frequency is large, and about 5dB also of attenuation has also improved it from 4 on the frequency higher than antiresonant frequency. Moreover, the filtering property at the time of connecting with the center IDT3 (input) side of drawing 1 is shown in drawing 4 instead of connecting one SAW resonator 2 to both sides IDT. If a SAW resonator is connected to a center IDT3 (input) side with reference to drawing 4 so that clearly, the cut-off characteristic by the side of the high region near the pass band will not become smooth, but a DIP as shown in drawing 4 will appear. Furthermore, when antiresonant frequency approaches a pass band, a pass band quantity region side will be missing, and it will be more roundish.

[0016] The difference in the filtering property which was shown in a filtering property and drawing 4 with what [good] is shown in drawing 3 and which deteriorated has unsymmetrical I/O of a filter, and since the impedance characteristics of I/O differ, it takes place. Although the Prior art had not shown clearly whether the SAW resonator which carries out series connection should be connected to which [by the side of IDT3 of the vertical joint DMS filter 1, or common connection of IDT(s) 4a and 4b] side, it has realized a good property like example drawing 3 for this clearly in this invention. That is, when connecting two or more SAW resonators to a vertical joint DMS filter at a serial and raising the attenuation by the side of the RF near the pass band, if a resonator with low antiresonant frequency is connected to the common terminal of IDT(s) 4a and 4b and a resonator with high antiresonant frequency is connected to the common terminal of IDT(s) 4a and 4b, or IDT3, a cut-off characteristic will not become round but will turn into a steep cut-off characteristic. When series connection of

drawing 2 (a). The frequency-impedance characteristic of the SAW resonator at the time of not giving weighting to IDT6 but on the other hand, considering as a normal mold does not show resonance as drawing 9 (a) mentioned above. It turns out that drawing 2 (b) is the transmission characteristic of the SAW resonator which carried out said cosine configuration weighting, the high region side of antiresonant frequency has small resonance also from this Fig., and the damping property is broad compared with drawing 9 (b) by this.

[0014] The manufacture terms and conditions of the SAW resonator in which a decussation finger is cosine configuration weighting and had the property of drawing 2 R> 2, and the SAW resonator which had the property of drawing 9 with the conventional normal mold IDT are made completely the same. Moreover, in the SAW resonator of the conventional normal mold IDT, as shown in drawing 9 (a), there are few amounts of reflection by the side of the high region of the pass band containing antiresonant frequency B, compared with drawing 2 (a), antiresonance is shallow, i.e., it turns out that the impedance of antiresonance is small. When the difference among these properties carries out series connection of the SAW resonator to a vertical joint DMS filter and uses it for it for a damping-property improvement, it appears as a difference of the superiority or inferiority of the attenuation by the side of the RF near the pass band. Namely, in the SAW resonator which becomes this invention shown in drawing 1 , as shown in drawing 2 , compared with the case where the SAW resonator which has the conventional property is used, the magnitude of attenuation can be earned in the larger range for the existence of small resonance to the RF side near the antiresonant frequency B. Furthermore, if the SAW resonator which has a property as shown in drawing is used, the amount of reflection by the side of the high region containing antiresonant frequency B will become large, and since a steeper cut-off characteristic and deep antiresonance, i.e., the neighboring impedance of antiresonant frequency B, are large, high attenuation can be obtained.

[0015] Drawing 3 is the example of a filtering property from which it constituted

the resonator with a frequency higher than the SAW resonator 2 is further carried out to the vertical joint DMS filter 1 of drawing 1 (concatenation is sufficient also as Center IDT side at a resonator 2) and the increment in the magnitude of attenuation is expected in it, since [of a pass band] the nearby cut-off characteristic is mostly determined by the resonator 2, whenever [steep] hardly changes to it with the case of drawing 1 very much. That is, with the filter configuration shown in drawing 1 , when raising whenever [by the side of the high region near the pass band / steep], if near attenuation level is obtained with the configuration of a resonator piece, it is not necessary to add a resonator further. If it adds, in a pass band, the increment in the loss for resonant resistance of a resonator will be caused on the contrary as usual.

[0017] In the property of the 3IDT length joint DMS filter simple substance shown in drawing 6 , the average insertion loss in the property of drawing 3 using the SAW resonator piece which becomes this invention is suppressed by the increment (1.8dB and only 0.3dB) to the average insertion loss within the about 35MHz bandwidth of pass bands being 1.5dB. However, in order to secure the magnitude of attenuation by the side of the RF near the pass band, when two SAW resonators by which the conventional proposal is made are used, as shown in drawing 10 , an average insertion loss will increase to 2.2dB. Received frequency is approaching [transmit frequencies] very much with 1477-1501MHz to 1429-1453MHz, and a domestic digital cellular phone (PDC) has the attenuation demand mentioned above especially in RF filter of a transmitting side. Since it is a big prerequisite that it is low loss, when it is going to realize this to coincidence by the SAW filter, it can be told to it that the configuration of drawing 1 in this invention is very effective.

[0018] In addition, the weighting configuration of the resonator in this invention is not what was restricted to the cosine (cos) mold, and if it has an ellipse or a similar form, effectiveness almost equivalent to having mentioned above will be acquired. Moreover, even if it connects a resonator with antiresonant frequency high further more to the configuration of this invention shown in drawing 1 at

Center IDT side, the outstanding cut-off characteristic in this invention is maintained, and can expect the increment in the magnitude of attenuation.

[0019]

[Effect of the Invention] This invention is set in the SAW length joint duplex mode type filter of 3IDT configurations. By connecting a resonator to the parallel connection terminal of both sides IDT at a serial, after taking an I/O impedance into consideration, and giving cosine (cos) or similar weighting to IDT of the resonator A deeper large antiresonance damping property can be acquired and the SAW filter which suppresses the increment in loss to minimum as a result, and has a damping property by the side of a good cut-off and high region close attendants can be realized.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the mimetic diagram of a configuration of improving the quantity region side magnitude of attenuation near the pass band of 3IDT duplex mode SAW filter proposed by this invention.

[Drawing 2] The Smith chart Fig. of the example of an impedance characteristic

of the series-connection cos weighting resonator for the filter magnitude-of-attenuation improvement which proposes (a) by this invention, and this drawing (b) are the examples of a transmission characteristic of said resonator.

[Drawing 3] It is the example of frequency characteristics of 3IDT duplex mode SAW filter which gave the improvement proposed by this invention.

[Drawing 4] It is the example of frequency characteristics at the time of carrying out series connection of the resonator to Center IDT side which suited the conventional proposal.

[Drawing 5] It is the mimetic diagram showing the configuration of 3IDT duplex mode SAW filter put in practical use as a conventional technique.

[Drawing 6] It is an example of frequency characteristics in the conventional 3IDT duplex mode SAW filter simple substance.

[Drawing 7] It is the mimetic diagram showing the configuration of the 3IDT duplex mode SAW filter property improving method by the resonator series connection by which the conventional proposal is made.

[Drawing 8] It is the mimetic diagram showing the principle of the method of 3IDT duplex mode SAW filter property improvement by resonator series connection.

[Drawing 9] (a) is the Smith chart Fig. of the impedance characteristic of the usual normal mold resonator, and (b) is the example of a transmission characteristic of said resonator.

[Drawing 10] Although it connected in the center IDT among the resonators linked to both I/O in the example of frequency characteristics of the filter shape improvement by which the conventional proposal is made, it is a filter, when fa is low and its direction is close to a filter pass band.

[Drawing 11] in drawing 10 , it is the same in both the antiresonant frequency of both resonators -- the example of a property at the time of bringing close to a ** filter pass band.

[Description of Notations]

1 3IDT Length Joint Duplex Mode Filter

2 One Terminal Pair Mold SAW Resonator of Cosine Mold Weighting

Decussation Finger Electrode

3, 4a, 4b, 6 IDT

5a, 5b, 7a, 7b Reflector

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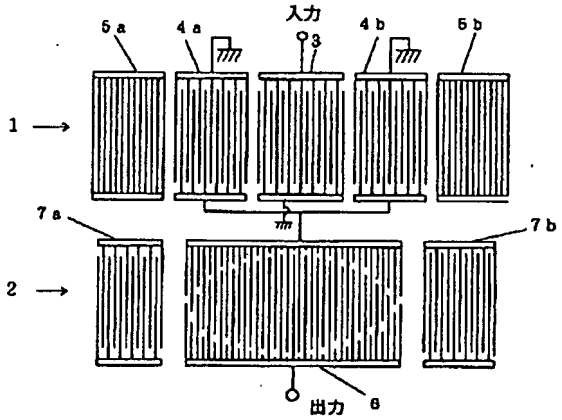
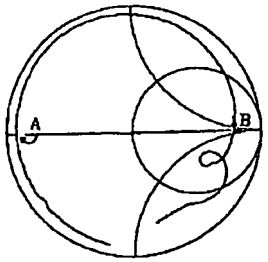
DRAWINGS

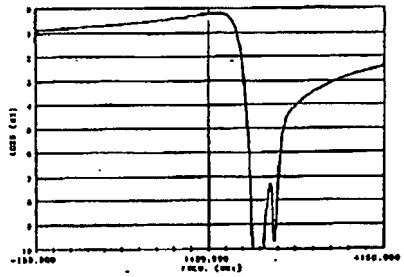
[Drawing 1]



[Drawing 2]

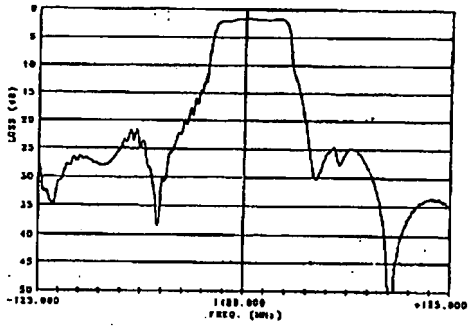


(a)

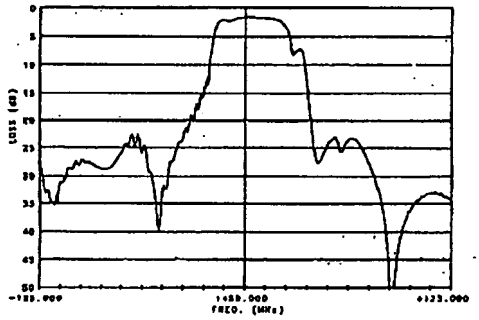


(b)

[Drawing 3]



[Drawing 4]



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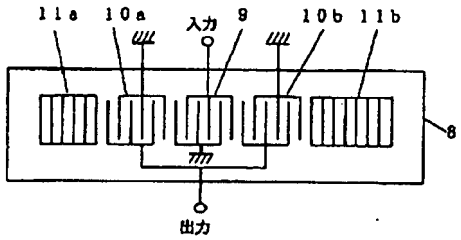
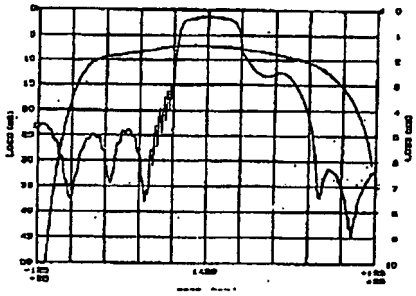
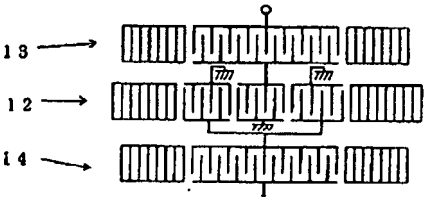


[Drawing 6]

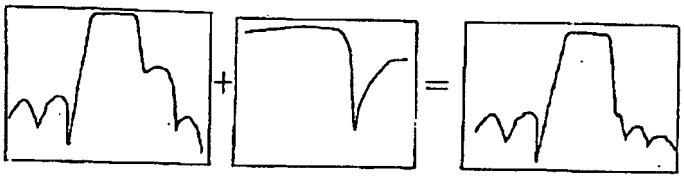


[Drawing 7]



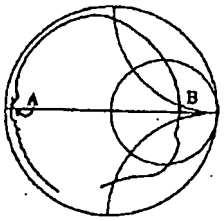
[Drawing 8]

(a)

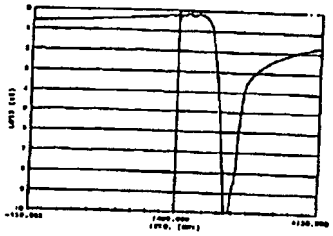


(b) (c) (d)

[Drawing 9]

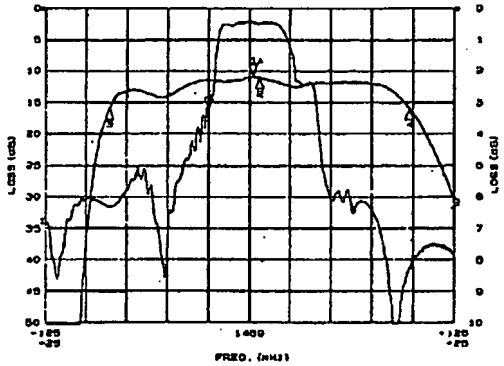


(a)

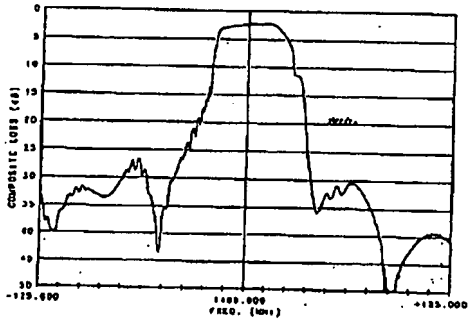


(b)

[Drawing 10]



[Drawing 11]



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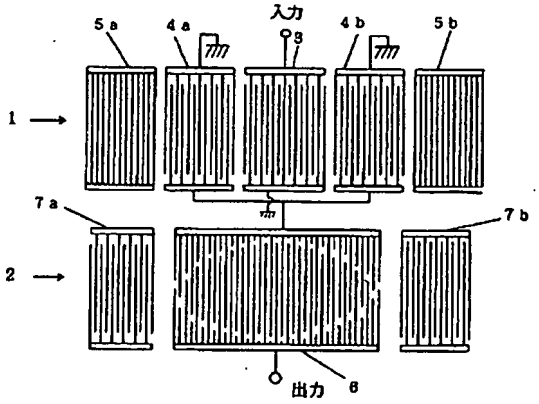
(54)【発明の名称】弾性表面波フィルタ

(57)【要約】
【課題】本発明は、弾性表面波（ＳＡＷ）に関し、通過域近傍の減衰特性に優れ、且つ、低挿入損失特性をもった３ＩＤＴ構成の縦結合２重モードＳＡＷフィルタ関する。
【解決手段】３ＩＤＴ２重モードＳＡＷフィルタの両側ＩＤＴを並列接続し更に、ＩＤＴにｃｏｓ型重み付けをしたＳＡＷ共振子を直列に接続する。



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【特許請求の範囲】

【請求項１】　圧電基板上に弾性表面波の伝搬方向に沿って配置した三個のＩＤＴと該ＩＤＴの両側に配置した二個の反射器とを備え、前記三個のＩＤＴのうち両側の二つのＩＤＴを並列に接続すると共にそのいずれか一方の連結端子にコサイン型重み付けをしたＩＤＴを接続し、且つ、その両側に反射器を配置し、該共振子の共振周波数を前記フィルタの通過域に、反共振周波数を前記フィルタの通過域よりも高周波側に設定したことを特徴とする弾性表面波フィルタ。

【請求項２】　前記圧電基板に回転３６度Ｙ板タンタル酸リチウムを用いたことを特徴とする請求項１記載の弾性表面波フィルタ。

【発明の詳細な説明】

【０００１】

【産業上利用分野】本発明は、圧電基板上に表面波伝搬方向に沿って、３個のインターディジタルトランスデューサ（以下、ＩＤＴと云う）および該ＩＤＴの最外側に２つの反射器を配置してなる弾性表面波フィルタ（以下、ＳＡＷフィルタと云う）に関し、特に通過域カットオフ特性および高域側近傍の減衰量を改善した弾性表面波フィルタに関する。

【０００２】

【従来の技術】弾性表面波はその振動領域が表面に限定されること、振幅と位相を別個に設計できること等、従来の振動デバイスに無い種々の特徴を有することから、基礎研究の分野でも応用の分野でも精力的に研究が成され、現在では、各種の装置に用いられている。中でも、小型、堅牢でありバッチ処理による大量生産に適していることから低コストが期待できるため、最近の移動体通信特に携帯電話等には多く使用されている。特に、Proc. of 1980 IEEE Ultrasonics Symposium pp.164-168において、Rosenberg R.L.およびColdren L.A.によって提案され、電子情報通信学会技報US-92-8で森田、渡辺らによって実用化された３ＩＤＴ構成の縦結合２重モードＳＡＷフィルタ（以下、縦結合ＤＭＳフィルタと云う）は、低損失であり、通過域が平坦でカットオフが急峻な特性を実現できるという優れた特徴を持っている。

【０００３】上記の３ＩＤＴ構成の縦結合ＤＭＳフィルタの模式図を図５に示す。縦結合ＤＭＳフィルタは圧電基板８の主表面に、伝搬方向に沿ってＩＤＴ９、１０ａ、１０ｂおよび該ＩＤＴの最外側に反射器１１ａ、１１ｂを近接して配置した構造を有し、ＩＤＴ９の対向する電極の一方を入力端子とし、他方を接地する。更に、図５のようにＩＤＴ１０ａ、１０ｂそれぞれの一方の電極を共通接続して出力端子とし、他方の電極を接地する。ここで、入力端子と出力端子は便宜的に決めたものであり、互いに入れ替えてもかまわない。

【０００４】図５に示すＩＤＴ９、１０ａ及び１０ｂと反射器１１ａ及び１１ｂの適正配置によって前記ＩＤＴ

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下に音響結合が生じ、その結果２つの閉じ込めモード即ち、一次縦モードと三次縦モードが、強勢に励起される。これらのモードの周波数をそれぞれｆ１とｆ３とすると、ｆ３＜ｆ１であり、中心周波数がｆ１で帯域幅が２（ｆ１－ｆ３）の縦結合ＤＭＳフィルタが得られる。図６に、３６度Ｙ－Ｘリチウムタンタレート（$LiTaO_3$）基板上に縦結合ＤＭＳフィルタを形成した場合の濾波特性の一例を示す。図６より明らかなように、通過域近傍の高域側に生ずる非対称特性は、入出力ＩＤＴの対数で決まる本質的なスプリアスで縦結合ＤＭＳフィルタ特有の欠点である。そのスプリアスの減衰量は１２～１３ｄＢ程しかなく、送受の周波数が近接している携帯電話用ＲＦフィルタに適用しようとする場合、大きな問題となる。

【０００５】上記通過域近傍のスプリアスを解決する手段として図７に示す様に、縦結合ＤＭＳフィルタ１２の入出力に一端子対型共振子１３、１４を直列に接続し、これら共振子の反共振周波数で構成する減衰極を利用して、通過域近傍の高域側の減衰量を改善しようとする提案が行われている。（長塚他、１９９４年信学会秋季大会、No.I.P.230、特開平７－３０３６７、特開平７－８６８７０）

【０００６】上記改善方法を図８を用いて説明する。図８（ａ）は縦結合ＤＭＳフィルタ（ＤＭＳＦと略記）の入出力にそれぞれ一端子対型ＳＡＷ共振子（以下、ＳＡＷ共振子と云う）を直列に接続した回路構成図を示す。図８（ｂ）は前記縦結合ＤＭＳフィルタの濾波特性（図６に相当）を示したもので、通過域近傍の高域側に上述したスプリアスが発生している。図８（ｃ）はＳＡＷ共振子の伝送特性を示したもので、反共振周波数に於いて減衰極が生じることを表している。該ＳＡＷ共振子の共振周波数を前記縦結合ＤＭＳフィルタの通過域とほぼ一致するように設定し、更に、反共振周波数を前記縦結合ＤＭＳフィルタの通過域近傍の高域側にあるスプリアスが発生する周波数とほぼ一致するように設定する。このように周波数を設定したＳＡＷ共振子を、図８（ａ）のように、縦結合ＤＭＳフィルタに直列接続すると、総合濾波特性は図８（ｄ）に示すように、縦結合ＤＭＳフィルタのスプリアスを改善した特性となる。

【０００７】図９に、前記ＳＡＷ共振子の実測値の一例を示す。図９（ａ）はＳＡＷ共振子の周波数－インピーダンス軌跡を表すスミスチャート図を示したものであり、円の直径の水平線は抵抗分（ｒ）を表し、円の上半分は正のリアクタンス（＋ｊｘ）を表し、下半分は負のリアクタンス（－ｊｘ）を表している。即ち、直径の水平線と交わる周波数が位相零の周波数であり、共振数波数Ａあるいは反共振周波数Ｂを表す。通常の正規型ＩＤＴを配設したＳＡＷ共振子の周波数－インピーダンス特性は、図９（ａ）に示すスミスチャート図からも明らかなように、反共振周波数Ｂの高周波側近傍で円を描くよ

うな軌跡はなく、共振は生じていない。また、前記ＳＡＷ共振子の伝送特性を測定すると図９（ｂ）に示すように、反共振周波数での単峰特性を示している。このような正規型ＩＤＴの共振子を用いて図７の如く構成したフィルタの濾波特性例を図１０に示す。周波数は約１．５ＧＨｚで帯域幅は約３６ＭＨｚである。縦結合ＤＭＳフィルタに直列接続するＳＡＷ共振子は一個または、２個以上でも、また入出力のいずれか片側だけでもよいし、共振子同士の周波数が互いにずれていてもよい。

【０００８】直列接続する上記ＳＡＷ共振子の共振周波数は、通常、ほぼフィルタ通過域内になるように設定するため、ＳＡＷ共振子追加による通過帯域に於ける損失の増加は僅かである。しかし、ＳＡＷ共振子の共振抵抗が１Ω程度のオーダーである以上、複数の共振子を直列接続すると、損失の増加を来たし問題となることは明らかである。また、１つの共振子の反共振点では、減衰を大きく保てる周波数範囲が狭いので、図７の様な回路構成の場合、２つの共振子の反共振周波数を互いに少しずらして配置するのが一般的であるが、この場合、通過域の損失の増加は、共振子一個の場合の約２倍となる。

【０００９】図１０は、図７のように縦結合ＤＭＳフィルタの入出力端子それぞれにＳＡＷ共振子を直列接続した構成の濾波特性例であり、周波数の低いＳＡＷ共振子を図７に示す中央ＩＤＴ（入力）側に接続している。通過域の高周波側にあるスプリアスの減衰量は改善されたが、カットオフ特性が滑らかではなく、台地のような部分が残っている。この台地のようなスプリアスを除くために、前記ＳＡＷ共振子の反共振周波数をさらにフィルタ通過域側に近接させると、図１１に示すよのように通過域特性の右肩が欠ける特性となる。

【００１０】

【発明が解決しようとする課題】しかしながら、従来のＳＡＷ共振子の直列接続による減衰量改善では、ある程度広い範囲で減衰量を確保する場合、反共振周波数をずらしたＳＡＷ共振子を２つ以上必要とした。また、縦結合ＤＭＳフィルタの入出力端子それぞれに接続するＳＡＷ共振子の高低の周波数関係を規定しておらず、場合によってカットオフ特性が滑らかにならず、フィルタ通過域特性の右肩が欠けることがあった。本発明はこれらの欠点を除去する為になされたものであって、共振子１つで従来よりも広い周波数範囲において一定の減衰量を確保し、通過域の損失増加を最小限にとどめること、および、良好なカットオフ特性を有する弾性表面波フィルタを提供することを目的とする。

【００１１】

【発明を解決するための手段】上記目的を達成するため本発明は、請求項１では、圧電基板上に弾性表面波の伝搬方向に沿って三個のＩＤＴ及び該ＩＤＴの最外側に二個の反射器を配置し、中央のＩＤＴを入力端子、両側の二つＩＤＴを並列接続して出力端子とした弾性表面波フィルタに直列に、コサイン型重み付けをしたＩＤＴとその両側の反射器とからなる一端子対型弾性表面波共振子を接続し、且つ、該共振子の共振周波数を前記フィルタの通過域に、反共振周波数を前記フィルタの通過域よりも高周波側に配置した弾性表面波フィルタである。更に、請求項２では、圧電基板に回転３６度Ｙ板タンタル酸リチウムを用いた弾性表面波フィルタである。

【００１２】

【発明の実施の形態】以下、本発明を図面に示した実施の形態と実験結果とに基づいて詳細に説明する。図１は本発明の構成を示したＩＤＴ電極の模式図であり、ＩＤＴ３、４ａ及び４ｂより構成する３ＩＤＴと、該ＩＤＴの最外側の反射器５ａ及び５ｂとで構成される縦結合ＤＭＳフィルタ１は、従来のものと同様であり、パターンのピッチや電極本数および各電極の間隔などは、所望の通過域を実現するように選ぶ。縦結合ＤＭＳフィルタ１の中央ＩＤＴ３の一方の電極を入力端子とし、他方の端子は接地する。また、ＩＤＴ４ａ及び４ｂのそれぞれの一方の電極を並列接続して出力端子とし、それぞれの他方の端子を接地する。更に、前記出力端子にＳＡＷ共振子２を直列に接続する。ＳＡＷ共振子２は、ＳＡＷを励振する電極指の交叉長がコサイン（ｃｏｓ）型重み付けしたＩＤＴ６とその両側の反射器７ａおよび７ｂとで構成されている。また、これらＩＤＴ及び反射器の電極パターンは圧電基板の主面上にアルミニウムまたはアルミニウム合金で作製する。

【００１３】本発明の要点は、縦結合ＤＭＳフィルタに直列に接続するＳＡＷ共振子のＩＤＴの電極指交叉長をコサイン形状にして、フィルタの総合濾波特性、特に、通過域近傍の高周波側の減衰量の改善と通過域のカットオフ特性を改善することである。ＩＤＴ６にコサイン型重み付けまたはこれに近い重み付けを施した場合の利点、およびＳＡＷ共振子をフィルタ１の両側ＩＤＴ（出力）側に接続した場合の利点について説明する。図２に、本発明になるＳＡＷ共振子の測定結果を示す。図２（ａ）は、ＳＡＷ共振子２を３６度Ｙ－Ｘリチウムタンタレート（$LiTaO_3$）基板上に作製した場合の周波数－インピーダンス特性のスミスチャート図であり、反共振周波数Ｂの付近で小さな円を描く軌跡がある。図２（ａ）よりＱの小さい共振が反共振周波数Ｂより少し高い周波数に存在することは明らかである。一方、ＩＤＴ６に重み付けを施さず正規型とした場合のＳＡＷ共振子の周波数－インピーダンス特性は、上述した図９（ａ）の通り共振を示していない。図２（ｂ）は前記コサイン形状重み付けをしたＳＡＷ共振子の伝送特性であり、本図からも、反共振周波数の高域側に小さな共振があり、これにより減衰特性が図９（ｂ）と比べて幅広くなっていることが分かる。

【００１４】交叉指がコサイン形状重み付けであって図２の特性をもったＳＡＷ共振子と、従来の正規型ＩＤＴ

で図９の特性をもったＳＡＷ共振子との製作諸条件は全く同一としてある。また、従来の正規型ＩＤＴのＳＡＷ共振子では、図９（ａ）に示したように反共振周波数Ｂを含む通過域の高域側での反射量が少なく、図２（ａ）と比べて反共振が浅い即ち、反共振のインピーダンスが小さいことが分かる。これらの特性の違いが、ＳＡＷ共振子を減衰特性改善のため、縦結合ＤＭＳフィルタに直列接続して用いる場合に、通過域近傍の高周波側に於ける減衰の優劣の差として表れる。即ち、図１に示した本発明になるＳＡＷ共振子では、図２に示す様に反共振周波数Ｂ近傍の高周波側に小さな共振の存在のため、従来の特性を有するＳＡＷ共振子を用いた場合に比べて、より広い範囲で減衰量をかせぐことができる。更に、図に示すような特性を有するＳＡＷ共振子を用いると反共振周波数Ｂを含む高域側での反射量が大きくなり、より急峻なカットオフ特性と深い反共振即ち、反共振周波数Ｂの近辺のインピーダンスが大きいので高減衰を得ることが出来る。

【００１５】図３は、図１の構成即ち、縦結合ＤＭＳフィルタと１個のＳＡＷ共振子とで構成し、且つＳＡＷ共振子の交叉指がコサイン形状のＩＤＴを用いて得られた濾波特性例であり、フィルタ通過域の右肩が欠けることなく急峻なカットオフ特性を実現出来ている。フィルタ特性が周知であるので、特に濾波特性を図示してないが、正規型ＩＤＴのＳＡＷ共振子を用いた場合と比べて、カットオフ特性は急峻で、反共振周波数での減衰が大きく、反共振周波数より高い周波数で減衰も４から５ｄＢ程改善している。また、１個のＳＡＷ共振子２を両側ＩＤＴに接続する代わりに、図１の中央ＩＤＴ３（入力）側に接続した場合の濾波特性を図４に示す。図４を参照して明らかなように、ＳＡＷ共振子を中央ＩＤＴ３（入力）側に接続すると、通過域近傍の高域側のカットオフ特性が滑らかにならず図４に示すようなディップが現れる。更に、反共振周波数が通過域に近づいた場合、通過域高域側が欠け、より丸みを帯びることになる。

【００１６】図３に示すの良好な濾波特性と図４に示した劣化した濾波特性の違いは、フィルタの入出力が非対称であり、入出力のインピーダンス特性が異なるために起こる。従来の技術は、直列接続するＳＡＷ共振子を、縦結合ＤＭＳフィルタ１のＩＤＴ３側、あるいはＩＤＴ４ａと４ｂの共通接続側のいずれの側に接続すべきかを明らかにしていなかったが、本発明では、これを明確に示し図３の様な良好な特性を実現できた。即ち、縦結合ＤＭＳフィルタに２個以上のＳＡＷ共振子を直列に接続して、通過域近傍の高周波側の減衰を高める場合、反共振周波数の低い共振子をＩＤＴ４ａと４ｂの共通端子に接続し、反共振周波数の高い共振子をＩＤＴ４ａと４ｂの共通端子あるいはＩＤＴ３に接続するとカットオフ特性が丸くならず急峻なカットオフ特性となる。図１の縦結合ＤＭＳフィルタ１に、ＳＡＷ共振子２よりも周波数の高い共振子をさらに直列接続して（中央ＩＤＴ側でも共振子２に縦続でもよい）、減衰量の増加を見込んだ場合、通過域のごく近傍のカットオフ特性は共振子２によってほぼ決定されているため、急峻度は図１の場合とほとんど変化しない。即ち、通過域近傍の高域側の急峻度を上げる場合、図１に示すフィルタ構成では共振子一個の構成でおおよその減衰レベルが得られていれば、共振子をさらに追加する必要はない。追加すれば、従来と同様にかえって通過域において共振子の共振抵抗分の損失の増加を引き起こす。

【００１７】図６に示した３ＩＤＴ縦結合ＤＭＳフィルタ単体の特性では、通過域約３５ＭＨｚバンド幅内での平均挿入損失が１．５ｄＢであるのに対し、本発明になるＳＡＷ共振子一個を用いた図３の特性での平均挿入損失は１．８ｄＢとわずか０．３ｄＢの増加に抑えられている。しかし、通過域近傍の高周波側の減衰量を確保するため、従来提案されている二個のＳＡＷ共振子を用いた場合、図１０に示すように平均挿入損失は２．２ｄＢまで増加してしまう。国内デジタル携帯電話（ＰＤＣ）は、送信周波数が１４２９～１４５３ＭＨｚに対し、受信周波数が１４７７～１５０１ＭＨｚと非常に接近しており、特に送信側のＲＦフィルタに上述した減衰要求がある。同時に、低損失であることが大きな前提条件であるので、これをＳＡＷフィルタで実現しようとする場合、本発明における図１の構成は極めて有効であると言える。

【００１８】なお、本発明における共振子の重み付け形状は、コサイン（ｃｏｓ）型に限ったものではなく、楕円もしくは類似の形をしていれば、上述したのとほぼ同等の効果が得られる。また、図１に示した本発明の構成にさらに、より反共振周波数の高い共振子を中央ＩＤＴ側に接続しても、本発明における優れたカットオフ特性は維持され、減衰量の増加が見込める。

【００１９】

【発明の効果】本発明は、３ＩＤＴ構成のＳＡＷ縦結合２重モード型フィルタにおいて、入出力インピーダンスを考慮したうえで両側ＩＤＴの並列接続端子に直列に共振子を接続し、また、その共振子のＩＤＴにコサイン（ｃｏｓ）または類似の重み付けを施すことによって、より深く広い反共振減衰特性を得るもので、結果として損失の増加を最低限に抑え、且つ、良好なカットオフおよび高域側近傍の減衰特性を有するＳＡＷフィルタが実現することができる。

【図面の簡単な説明】

【図１】本発明で提案する３ＩＤＴ２重モードＳＡＷフィルタの通過域近傍高域側減衰量を改善する構成の模式図である。

【図２】（ａ）は、本発明で提案するフィルタ減衰量改善のための直列接続ｃｏｓ重み付け共振子のインピーダンス特性例のスミスチャート図、同図（ｂ）は、前記共

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振子の伝送特性例である。

【図３】本発明で提案する改善を施した３ＩＤＴ２重モードＳＡＷフィルタの周波数特性例である。

【図４】従来提案にあった、中央ＩＤＴ側に共振子を直列接続した場合の周波数特性例である。

【図５】従来技術として実用化されている３ＩＤＴ２重モードＳＡＷフィルタの構成を示す模式図である。

【図６】従来の３ＩＤＴ２重モードＳＡＷフィルタ単体での周波数特性例である。

【図７】従来提案されている共振子直列接続による３ＩＤＴ２重モードＳＡＷフィルタ特性改善法の構成を示す模式図である。

【図８】共振子直列接続による３ＩＤＴ２重モードＳＡＷフィルタ特性改善方の原理を示す模式図である。

【図９】（ａ）は通常の正規型共振子のインピーダンス

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特性のスミスチャート図、（ｂ）は、前記共振子の伝送特性例である。

【図１０】従来提案されているフィルタ特性改善の周波数特性例で、入出力両方に接続した共振子のうち中央ＩＤＴに接続したものの方がfaが低くフィルタ通過域に近い場合フィルタ。

【図１１】図１０において、両共振子の反共振周波数を共に同じだけフィルタ通過域に近づけた場合の特性例。

【符号の説明】

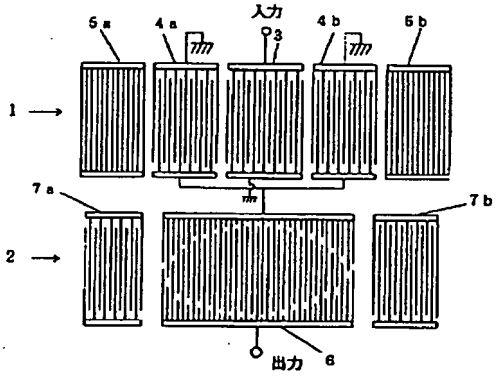
1　　３ＩＤＴ縦結合二重モードフィルタ

2　　コサイン型重み付け交叉指電極の一端子対型ＳＡＷ共振子

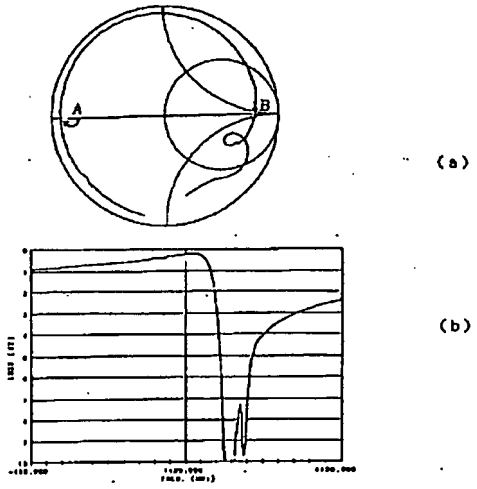
3、４ａ、４ｂ、６　　ＩＤＴ

５ａ、５ｂ、７ａ、７ｂ　　反射器

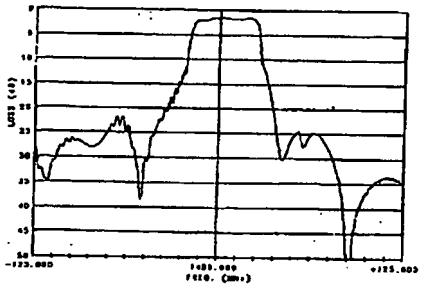
【図１】



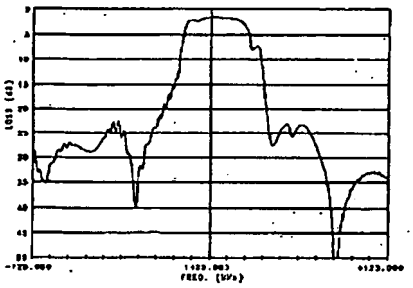
【図２】



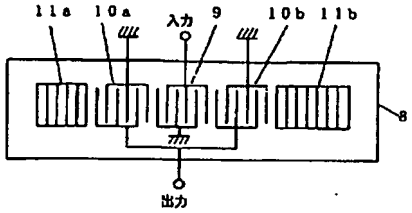
【図３】



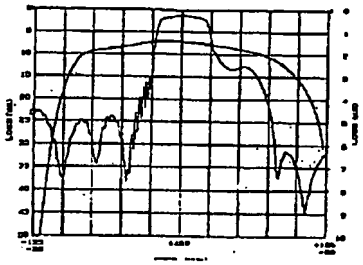
【図４】



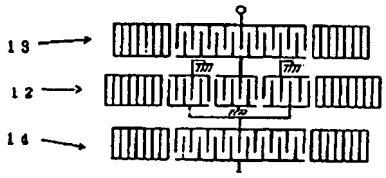
【図５】



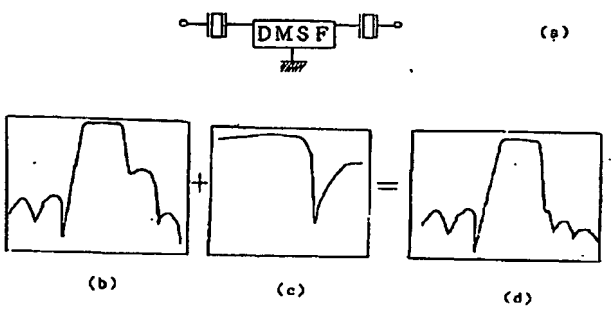
【図６】



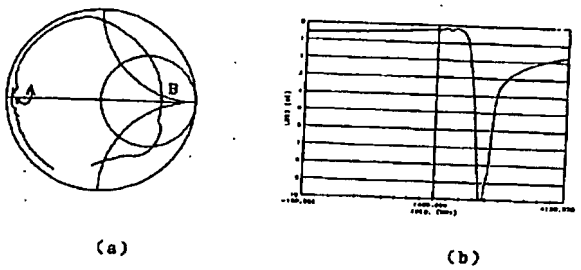
【図７】



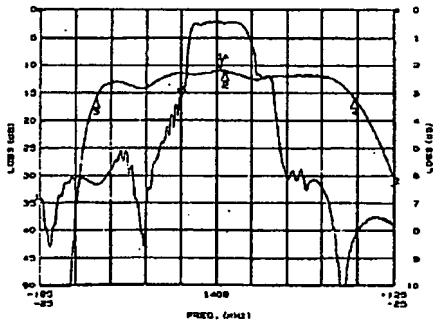
【図８】



【図９】



【図１０】



【図１１】